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Materials Based on Magnesium for Energy Storage and Conversion

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INTRODUCTION

To realise the sustainable and low-carbon society for which China pledged the long-term strategic aim to reach peak carbon dioxide (CO_2) emissions by 2030 and achieve carbon neutrality by 2060, materials for energy conversion and storage systems must be developed. Because advancements in this field can increase the efficiency with which intermittent renewable energy is harvested, level out fluctuations in production and consumption, distribute and transport the energy, develop incredibly efficient technologies for portable electronics, electric vehicles, and other uses, and decrease the overall consumption of fossil fuels. Due to their favourable environmental effects, ample geological reserves, and high energy density in the fields of hydrogen storage and batteries, magnesium (Mg)-based materials are among the most significant, promising, and quickly developing materials in the field of energy conversion and storage systems.

The hydrogen storage properties of Mg-based materials, including thermodynamic, kinetic, and cycling properties, have been greatly improved, and the Mg-based cell with an anodic utilisation efficiency of 82% is achieved. In recent years, significant efforts have been made on Mg-based H_2 storage materials and Mg-based batteries. Future advancements in the low cost preparation technology, the stable performance, and the extended service life of materials based on magnesium are required for their application. Therefore, significant technical innovation and challenges must always be handled pro-actively. Examples include (1) combining Mg-base materials with nanostructure design and emerging technologies; (2) understanding thermodynamics and dynamics and how they affect Mg-based materials' performance; (3) understanding highly efficient catalysts and how they work; and (4) understanding the compatibility of Mg-based materials with the electrolyte.

The editors will offer a selection of the most cutting-edge novel findings on Mg-based materials connected to H_2 storage and batteries in the current special issue, taking into account the significant advancement gained in recent years. To highlight research trends, describe sophisticated preparation techniques for cutting-edge materials, and summarise relevant comprehensive characterisation technologies, ten peer-reviewed articles have been chosen.

One of the most promising options for meeting the capacity requirements for on-board vehicles is magnesium-based hydride. A thorough evaluation of the most appealing systems and their hydrogenation/dehydrogenation characteristics was. In particular, they highlighted the community's efforts to enhance the material's thermodynamic and kinetic characteristics while preserving a high H_2 storage capacity. TEM, SEM, and PCI techniques were used to thoroughly evaluate the impact of the Co@C catalyst on the H_2 storage behaviour of the $Mg_{90}Ce_5Y_5$ alloy. The carbon nanosheet and Co nanoparticle defects, which efficiently lower the energy barriers for the nucleation of the Mg/MgH_2 phase and accelerate the recombination of the hydrogen molecule, are credited with the favourable effect. $La_7Sm_3Mg_{80}Ni_{10}$ composite's H_2 storage capabilities were discussed. Due to the lower activation energy of H_2 desorption, TiO_2 and La_2O_3 doping enhanced the composite's reaction kinetics. Furthermore, the H_2 storage process of MgH_2 is very well catalysed by carbon-based materials. Tan group reported the synthesis of a carbon-supported Ni_3S_2 catalyst via a simple chemical pathway employing nickel acetate tetrahydrate and ion exchange resin as precursors. The resultant catalyst was applied to enhance MgH_2's H_2 storing capabilities. While investigation, the hydrolysis of MgLi-graphite composites as viable options for secure and practical hydrogen release in addition to H_2 storage. In the MgLi-10 wt% graphite composite, favourable H_2 conversion efficiency and quick reaction kinetics were both observed. Similar work was presented by Bobet group that the hydrolysis reaction and corrosion behavior of AZ91 with graphite or $AlCl_3$ was investigated by polarization curve and electrochemical impedance spectroscopy. To date, the main-hurdle for the commercialization of Mg-based H_2 storage materials is the high operating temperature and slow dehydrogenation rate, which is caused by the sluggish kinetics.

Due to the advantages of high Coulombic efficiency (nearly 100%), high specific volumetric capacity (3833 mA h cm^3 vs. Li metal: 2046 mA h cm^3), and good capacity retention (95% after 1000 cycles), Mg-based materials are also investigated as the next-generation battery materials (the anode for Mg-ion, and Mg-Air batteries). These in-depth investigations are anticipated to inspire a solution to the aforementioned Mg-ion battery problems. The impact of alloying components on the battery discharge characteristics of the Mg alloy anode was comprehensively analysed. To provide a thorough grasp of high-performance Mg-air batteries from the perspectives of theoretical and practical considerations, the present issues and perspectives are also examined. In order to better understand the production mechanism of the AB4-type phase,while researching, the phase change of their artificial rare-earth-Mg-Ni-based alloy. It was found that the discharge characteristics and electrochemical behaviours of the as-cast AZ80-La-Gd anode for Mg-air batteries. According to the findings, the modified AZ80-La-Gd anode material has excellent electrochemical stability and catalytic efficiency, making it a perfect choice for Mg-air batteries. The self-supporting nanoporous Bi electrodes have adequate Mg storage performance. Additionally, the alloy-typed anodes work well with standard electrolytes.